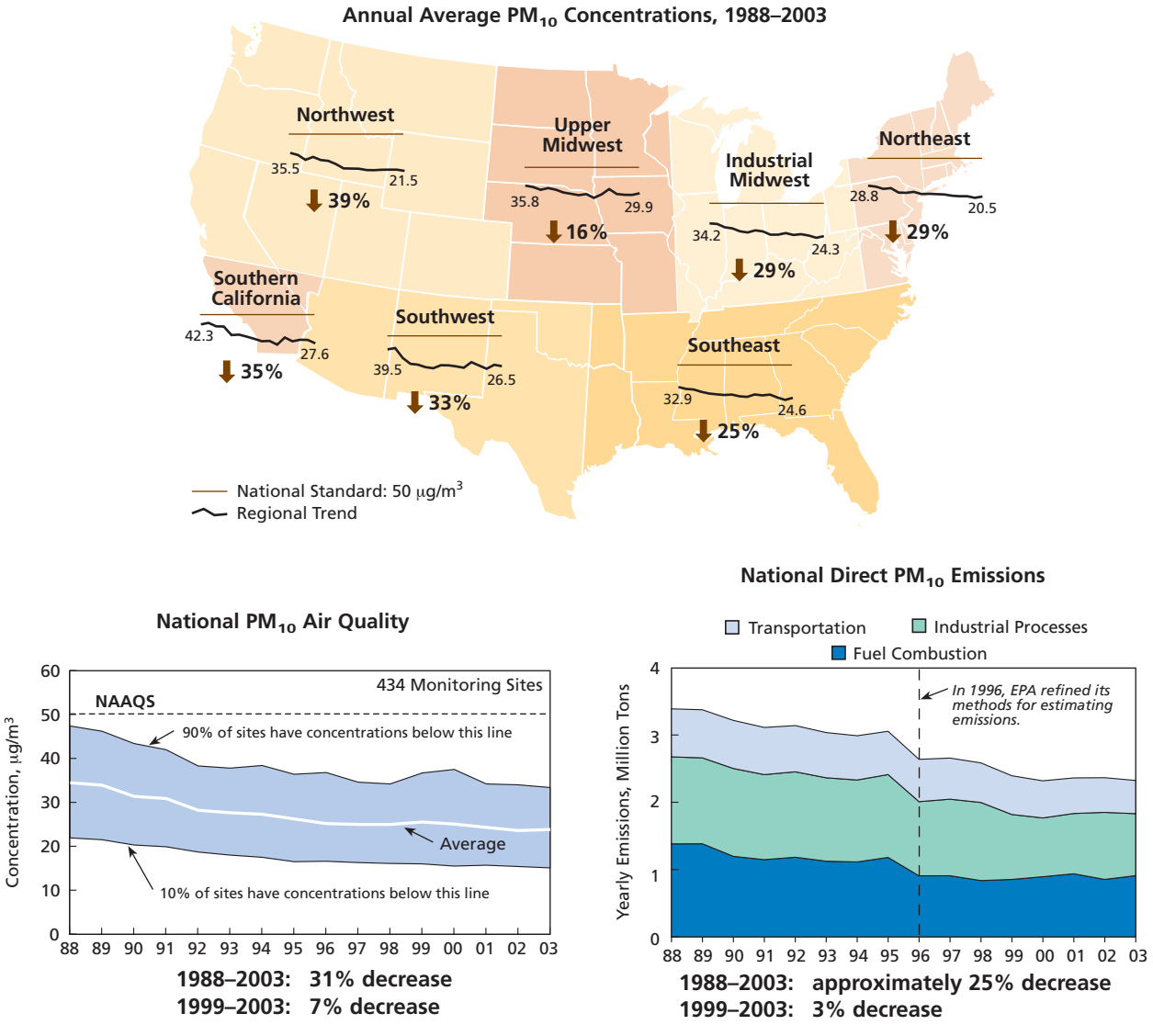
Looking at Trends

PM_{10} National and Regional Trends

Nationally, PM_{10} concentrations have decreased 31% since 1988, as shown in Figure 12. Regionally, PM_{10} decreased most in areas with historically higher concentrations — the Northwest (39%), the Southwest (33%), and southern California (35%).

Programs aimed at reducing direct emissions of particles have played an important role in reducing PM_{10} concentrations, particularly in western areas. Some examples of PM_{10} controls include paving unpaved roads, replacing wood and coal with cleaner-burning fuels like natural gas, and using best management practices for agricultural sources of resuspended soil. Additionally, EPA's Acid Rain Program has substantially reduced SO_2 emissions from power plants since 1995 in the eastern United States, contributing to lower PM concentrations. Direct emissions of PM_{10} have decreased approximately 25% nationally since 1988.

Figure 12. Regional and national trends in annual average PM_{10} concentrations and emissions, 1988–2003.

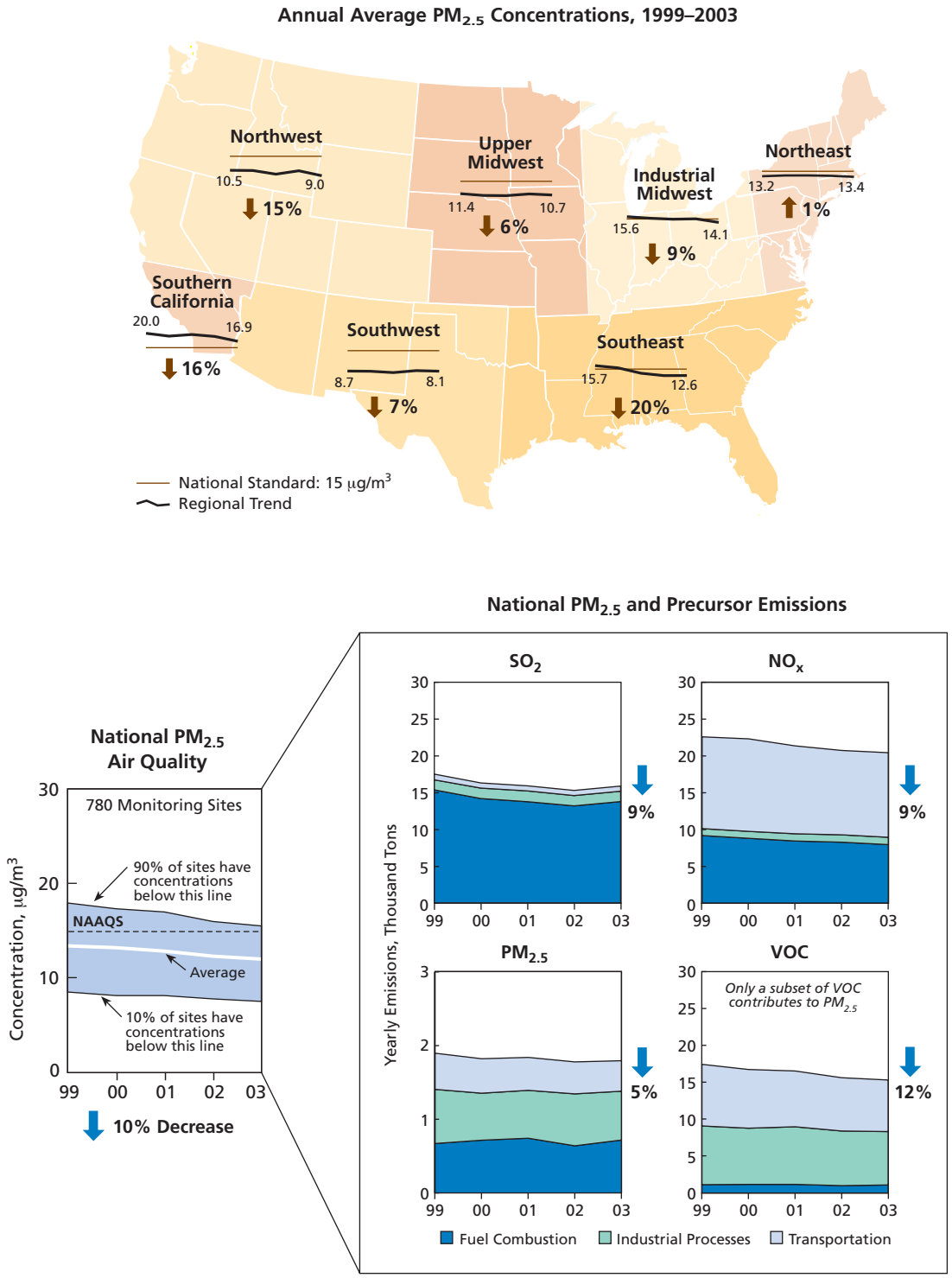


$PM_{2.5}$ National and Regional Trends

$PM_{2.5}$ concentrations have decreased 10% nationally since 1999. Generally, $PM_{2.5}$ has decreased the most in regions with the highest concentrations — the Southeast (20%), southern California (16%), and the Industrial Midwest (9%), as shown in Figure 13. With the exception of the Northeast, the remaining regions posted modest declines in $PM_{2.5}$ from 1999 to 2003.

A variety of local and national programs have resulted in a 5% decrease in estimated direct emissions of $PM_{2.5}$ over the past 5 years. In addition, programs that reduce the gaseous emissions that can form particles in the atmosphere have yielded additional reductions. National programs that affect regional emissions — including EPA's Acid Rain Program — have contributed to lower sulfate concentrations and, consequently, to lower $PM_{2.5}$ concentrations, particularly in the Industrial Midwest and Southeast. National ozone-reduction programs designed to reduce emissions of volatile organic compounds (VOCs) and nitrogen oxides (NO_x) also have helped reduce carbon and nitrates, both of which are components of $PM_{2.5}$. Nationally, SO_2, NO_x, and VOC emissions decreased 9%, 9%, and 12%, respectively, from 1999 to 2003. In eastern states affected by the Acid Rain Program, sulfates decreased 7% over the same period.

Figure 13. Regional and national trends in annual average $PM_{2.5}$ concentrations and emissions related to $PM_{2.5}$ formation, 1999–2003.



Note: Ammonia is a contributor to $PM_{2.5}$ formation. However, because of uncertainty in ammonia emission estimates, its trends are not shown here.

25-Year $PM_{2.5}$ Trends

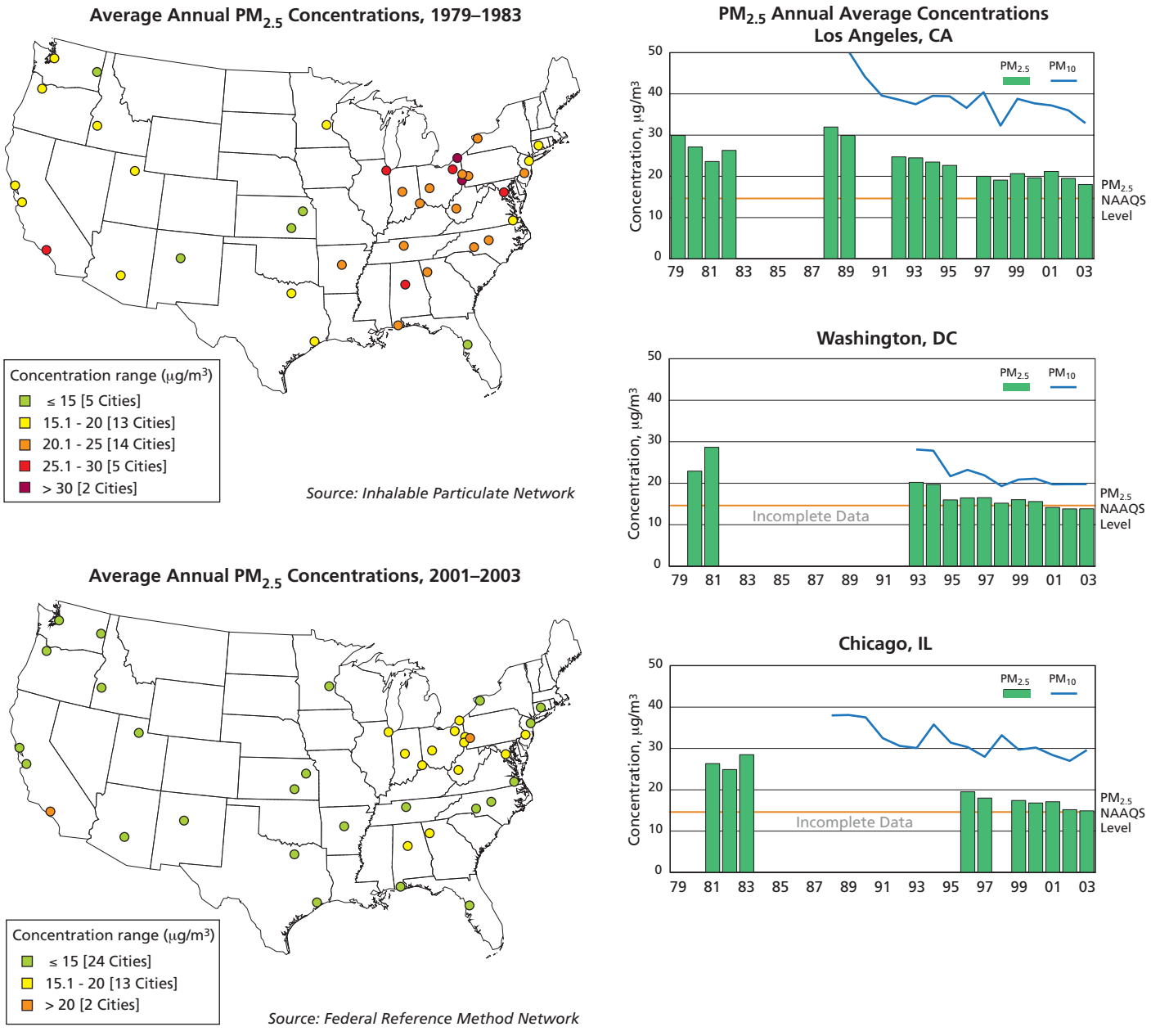
Because EPA's national $PM_{2.5}$ monitoring network is just 5 years old, we use data from older $PM_{2.5}$ monitoring networks to assess longer-term trends. Although the earlier networks are more limited in geographic scope and years of coverage, their data do provide historical perspective. The maps in Figure 14 show how $PM_{2.5}$ concentrations 25 years ago compare with $PM_{2.5}$ concentrations today in 39 major cities. Reductions vary among the 39 cities. Generally, the largest reductions occurred in the areas with the highest concentrations. On average, today's levels are about 30% lower than they were 25 years ago.

The following examples, illustrated in Figure 14, show how $PM_{2.5}$ concentrations have improved over the past 25 years in three cities. Figure 14 also shows PM_{10} concentrations for comparison (where available). $PM_{2.5}$ accounts for more than half of the PM_{10} levels in these areas.

- **Los Angeles:** $PM_{2.5}$ concentrations have decreased substantially since 1980. Although concentrations have leveled off in recent years, average $PM_{2.5}$ levels in 2003 were the lowest on record. Low-sulfur gasoline use and ozone reduction programs designed to control NO_x and VOC emissions may have contributed to the $PM_{2.5}$ decrease observed in the 1990s.
- **Washington, DC:** $PM_{2.5}$ concentrations are currently (2003) at their lowest levels. The relatively large drop from 1994 to 1995 corresponds to decreases in sulfates (21%) and organic carbon (30%). The decrease in sulfates is attributable in part to the Acid Rain Program, which substantially reduced SO_2 emissions from power plants during this time. The decrease in organic carbon is attributable in part to the use of reformulated gasoline.
- **Chicago:** $PM_{2.5}$ concentrations at this site have dropped substantially since the early 1980s, reaching their lowest levels in 2003.

For additional information on long-term trends, see www.epa.gov/airtrends/pm.html.

Figure 14. Comparison of historical $PM_{2.5}$ and PM_{10} annual average concentrations, 1979–2003.



Note: The 1979–1983 data are from the Inhalable Particulate Network (IPN). The 1984–1999 data are from EPA's Air Quality System. The 1999–2003 data are from the Federal Reference Method (FRM) network. The 1993–2003 data for Washington, DC, are from the IMPROVE network.

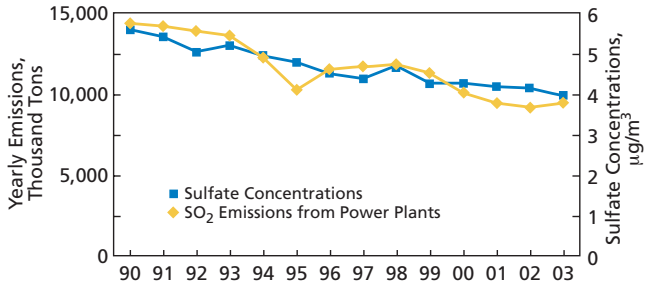
Rural Sulfate Trends

In the eastern half of the United States, sulfates account for 25% to 55% of $PM_{2.5}$ annually. Power plants are the largest contributor to sulfate formation in the East, where they were responsible for more than 75% of sulfur dioxide emissions in 2003.

In the East, power plants reduced sulfur dioxide emissions 33% between 1990 and 2003. As Figure 15 shows, this downward trend matches well with the trend in concentrations of rural sulfates (a 29% decrease). Because sulfates have such a large regional component (shown in Figure 6), these trends in sulfate concentration can also be used to help explain urban $PM_{2.5}$ trends.

The reductions shown in Figure 15 are primarily attributable to implementation of EPA's Acid Rain program. Phase I compliance began in 1995, affecting large coal-burning power plants in 21 eastern and midwestern states. Phase II implementation began in 2000, tightening emission limits on the Phase I power plants and setting restrictions on smaller coal-, oil-, and gas-fired plants. As the figure shows, sulfur dioxide emissions and sulfate concentrations decreased following implementation of both phases. A slight increase in SO_2 emissions in the latter half of the 1990s was likely due to power plants not affected until Phase II began in 2000. The small increase from 2002 to 2003 resulted from increased electricity production by coal-fired and oil-fired units. These units emit much more SO_2 than natural gas units that generated less power in 2003. This annual variation does not affect the total limit on SO_2 emissions under the Acid Rain Program. (For more information, see www.epa.gov/air/oap.html and www.epa.gov/acidrainreport/.)

Figure 15. Eastern annual trends of sulfur dioxide emissions from power plants and sulfate concentrations.



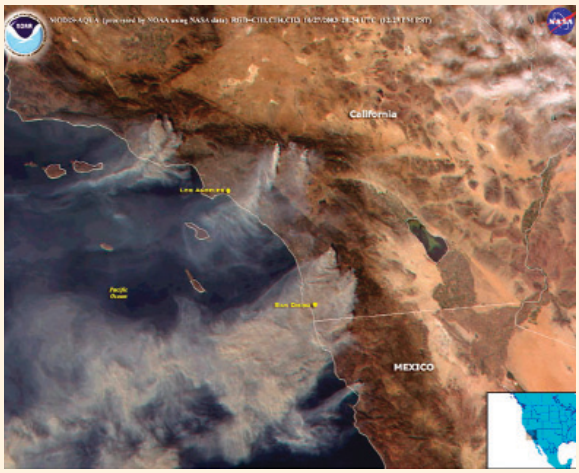
Note: Sulfate concentrations are from EPA's CASTNET monitoring network, www.epa.gov/castnet

Episodic Events

PM concentrations can increase dramatically due to human-caused or natural episodic events, such as biomass burning, meteorological inversions, dust storms, and volcanic and seismic activity. These events are rare, affecting less than 1% of reported $PM_{2.5}$ concentrations between 2001 and 2003. Episodic events can affect people's short-term PM exposure, briefly pushing hourly and daily PM levels into the unhealthy ranges of the Air Quality Index. However, these events rarely have a significant effect on annual or longer averages of PM.

Biomass burning can be either a human-initiated event, as in the burning of vegetation for land clearing or land use change, or a natural event, as in the wild fires resulting from lightning. Biomass burning can significantly increase PM levels in local areas and sometimes more distant areas. Air currents can carry smoke from forest fires half-way around the earth. Organic carbon compounds usually dominate the $PM_{2.5}$ concentration profile during these fire episodes.

Topography and meteorological conditions make some areas more susceptible to episodic events. In mountain regions, temperature inversions sometimes trap polluted air during the winter. Wintertime $PM_{2.5}$ and PM_{10} can be more than three times higher than other seasonal averages. Woodstove smoke, containing large amounts

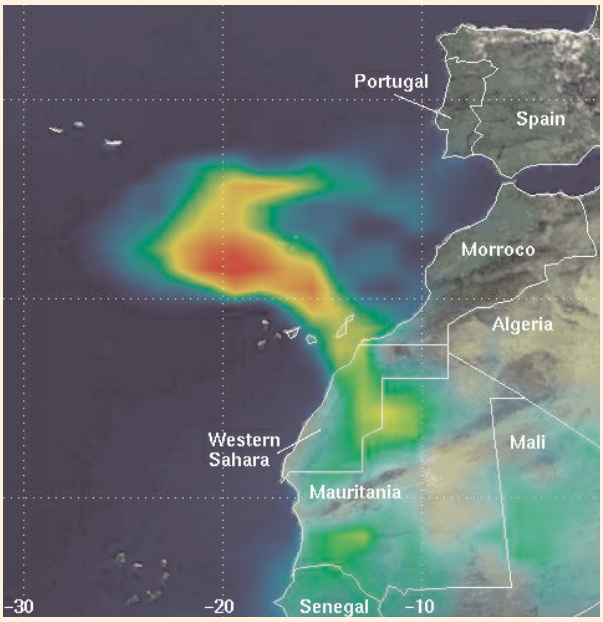


Satellite photo of forest fires, southern California, October 27, 2003.

of organic carbon, is often identified as a significant source of the elevated wintertime PM concentrations.

Arid desert conditions in the southwestern United States make this region more vulnerable to wind-blown dust than other regions of the nation. Most dust events are caused by passage of weather fronts and troughs and downmixing of upper-level winds. Cyclone development and thunderstorms result in the most dramatic dust clouds with the lowest visibilities. Dust-related events are typically dominated by large, coarse particles, but fine particle levels also increase.

The effects of dust storms can also be seen globally. Giant sand storms originating in the Sahara Desert can blow across the Atlantic to South America, the Caribbean, and the southeastern United States, transporting several hundred million tons of dust each year. Movement of dust from Africa has increased since 1970 because of an increase of dry weather in the Saharan region. Satellite pictures also confirm that sandstorms originating in China's Gobi Desert occasionally cross the Pacific to the United States. Transport from Africa typically occurs in the summer, and transport from Asia typically occurs in the spring.



Satellite photo of giant cloud of dust originating in North Africa moving westward.

Temperature inversion, Salt Lake Valley, Utah, January 13, 2004.

Dust storm, Phoenix, Arizona, August 19, 1999.